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March 1937

DEPARTMENT OF THE INTERIOR

UNITED STATES BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

RÉSUMÉ OF RESEARCH AND TECHNOLOGIC WORK RELATING TO COAL CONDUCTED BY THE TECHNOLOGIC BRANCH DURING 1936

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BY

ARNO C. FIELDNER

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RÉSUMÉ OF RESEARCH AND TECHNOLOGIC WORK RELATING TO COAL CONDUCTED BY THE TECHNOLOGIC BRANCH DURING 1936[1]

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By Arno C. Fieldner[2]

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PROPERTIES AND COMPOSITION OF COAL

One of the important objectives of the Bureau of Mines is the improvement and enlargement of its program for surveying the composition and properties of American coals. The need of such information is increasing, not only to meet the requirements of consumers but also to give the data required for establishing the classifications upon which various plans for stabilizing the industry rest.

Fuel Inspection and Coal Analyses. During the year approximately 8,000 analyses of coal and coke have been made, 78 reports involving 10,011 determinations being completed during a single month. These analyses were made in connection with the purchase of coal for Government use, with surveys of national coal resources, with mine safety investigations, and as a part of the research programs of the Bureau. Analytical studies usually form an essential portion of most research developments, and this is true of coal research. Some 15 to 20 percent of the coal analyses are made at the request of Bureau research workers. All the analyses are available to Federal and State agencies as an aid in purchasing fuel to the best advantage. A public file of coal analyses is kept current for reference and is available to companies and bidders.

Field activities are conducted with two sampling trucks. One of these is now completing a program of tipple sampling at all the mines of Alabama. Analyses of coal by States are continually being prepared for publication as Bureau of Mines Technical Papers. Manuscripts covering coal analyses of New Mexico (T. P. 569, off press Dec. 12) and of Colorado (T. P. 574, in press) are completed, and progress is reported on the manuscript on Pennsylvania coals.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Info. Circ. 6935."

[2] Chief, Technologic Branch, U. S. Bureau of Mines, Washington, D. C.

The laboratory has been authorized to include in coal analyses of tipp and face samples the classification by rank and the agglomerating propertie of the coal, these being determined by the American Society for Testing Materials Tentative Methods (D 388 - 36 T). The Bureau of Mines took a maj part in the work of developing these classificatory methods, recently adopt as Tentative American Standards by the American Standards Association.[3]

Agglutinating Value of Coal. A test method has been developed by the Burea for determining the caking characteristics o coal. Sand in definite amounts is mixed with a weighed portion of coal, th mixture is heated to 950° C. for 20 minutes, and the crushing strength of t coke button so formed is then determined. The rough correlation between th strength of the coke and agglutinating power has proved of value in detect differences in coking properties that may occur in different layers of coa from the same bed and in determining the effect of weathering on coking pr erties. The method has been published by the American Society for Testin Materials as a proposed tentative standard for measuring the "agglutinati value" of coal.

Grindability of Coal. The Bureau has conducted research at the Seattle, (Washington), Tuscaloosa (Alabama), and Pittsburgh (Pennsylvania) stations on the friability and grindability of coal; one of the new tentative methods of the A. S. T. M. is the Bureau of Mines ball-mill method.

The grindability of coal has an important bearing upon pulverized-coa costs, and a simple method for estimating this property has been needed g ly. Further investigation of the method developed by the Bureau has show it gives a reliable measure of the work required to grind a coal whose con ents have different degrees of hardness.[4]

Constitution of Coal. The Bureau of Mines has endeavored to maintain the position it has attained by pioneering investigati of coal constitution with paleobotanical methods, utilizing particularly microscope. During 1936, in addition to fundamental research of this cha attention has been given to coal petrography in conjunction with other me for determining the carbonizing properties of American coals.

In the development of methods for ascertaining the gas- and coke-mak properties of American coals, the coal-constitution laboratory made micro scopical and petrographical examinations of columnar sections of various In each instance a complete series of thin sections from top to bottom of column was prepared and examined microscopically with respect to the natu and relative amounts of its constituents. By means of these data each b

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[3] Barkley, J. F., and Burdick, L. R., Curves for the Classification of Info. Circ., Bureau of Mines, (in press).

[4] Yancey, H. F., and Geer, M. R., Further Investigation of Methods for mating the Grindability of Coal: Trans. Am. Inst. Min. and Met. E Coal Division, vol. 119, 1936, pp. 353-379; Combustion, vol. 7, Ma 1936, pp. 37-39.

as separated into types and subtypes, and the percentage of splint, semi-
plint, and bright coal was determined for each bed. For example, according
o the microscopical examination of the 65 thin sections of the Vigo County,
nd., No. 4 bed, the column sample was divided into three layers:

Bottom	17.5 in.	bright coal
Middle	22.7 in.	mixture of bright, semisplint, and splint
Top	28.8 in.	bright coal

he types were separated from the column samples and submitted for proximate
nd ultimate chemical analyses, low-temperature distillation assays, and
oking properties.

Ash, volatile matter, and fixed carbon were found to be the greatest
ariables in the different benches. Behavior of the coal cannot be predicted
n the basis of chemical analyses alone. The coke and tar yields were not
onstant, but usually the gas yield from bright coal was considerably higher
han from splint. With some exceptions (1 in 12, to date) bright coals had
ar higher agglutinating values than splint coals. Splint-coal coke was
ense, with few cellular spaces, and indicated little swelling, while bright-
oal coke contained many large pores, appeared more friable, and showed two
r three times as much swelling as the splint. These complete data were
abulated for possible statistical deductions.

Recent observations in the study of the origin and composition of coal
dicate the granular opaque matter (a characteristic constituent of splint
oals) to be derived chiefly from conifers, and subsequent findings indicate
t to be from the secondary walls of the wood fibers, which have finally formed
ery small, almost submicroscopic, dark particles.[5] Evidence also points
o the origin of another typical substance of splint coal, the brown or semi-
ranslucent matter resulting from the bark of some plant contributing to the
oal. Both are extremely significant findings for those studying the consti-
tion of coal.

There is proposed a systematic investigation of the origin, composition,
nd structure of lignites and subbituminous coals to facilitate their utiliza-
ion since they are coming and must in the future come more and more to the
ront as a fuel and as a source of raw materials in the production of motor
uel and chemical products. As the coal-hydrogenation studies proceed, the
icroscopic examination of various coal constituents will be correlated with
heir hydrogenating characteristics.

A continuation of the problem of the effect of heat on coal as revealed
y the microscope is intended because the preliminary work has been satisfactory
n revealing the differential behavior of the various constituents in coal under
ifferent heat treatments and in explaining a number of phenomena experienced
n coking.

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[5] Thiessen, R., and Sprunk, G. C., The Origin of the Finely Divided or Granular Opaque Matter in Splint Coals: Fuel in Science and Practice, vol. 15, no. 11, 1936, pp. 304-315.

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Weathering of Coal. Large consumers of coal usually are required to store some coal because of the possibility of interruptions to supply such as from strikes, the failure of transportation, or major physical disasters. Insufficient scientific attention has been given to th effect of weathering on stored coal. It has been known that there must be a slow oxidation of certain components. In highly fusible coals a certain degree of oxidation improves the coke. Experiments, involving dry coal exposed under known conditions of humidity, are now in progress to determine the effect of slow oxidation at ordinary temperatures on the quality of the coke and byproducts. The oxidation is allowed to proceed in a rotating dru under controlled conditions and the product then coked in the Bureau of Min carbonization test unit. A paper showing the beneficial effects of weather on Pittsburgh bed coal has been published.[6] Closely correlated is the que of the effect of treatment with oil upon the weathering of coal. Such trea ment has been widely adopted to control dust production, but the concomitan effect upon oxidation apparently has not been studied.

Plasticity of Coal. When a caking coal is heated either in a fuel bed or a coke oven it undergoes partial fusion, swells, and together. This stage of fusion is known as the plastic range of the coal. The degree of plasticity developed, the temperature range in which it occu and the nature of the coke formed are important both in burning coals and making coke. A fundamental study of this phenomenon and of methods for eva ating plasticity is in progress at the Pittsburgh station.

A new plastometer for measuring the plastic properties of the coke ha been devised. The coal is heated at a rate comparable to that it would en counter if it passed the plastic range in a commercial coke oven, and at th same time it is stirred by rabble arms that measure the resistance to shea The length of the plastic range and the degree of plasticity observed are correlated to the strength and density of the coke and the performance of coal in stoker-fired furnaces. An initial paper on the subject was publis

COAL MINING

The Bureau's work dealing directly with coal mining is conducted in t Technologic and the Health and Safety Branches.

The Technologic Branch conducts research and collects engineering dat mining, ventilation, explosives (including their permissibility and use), movement of strata, the permissibility and efficiency of electrical and me cal equipment, the mechanism of the ignition and propagation of gas and du explosions and the development of means for their prevention, and the sour of mine fires and methods for their early detection and control.

The Health and Safety Branch maintains a field force which conducts t training of miners and other workers in the mineral industries with refere o such matters as safe practices, mine rescue methods, and procedures for con- rolling mine fires. It educates operators and workers in the improvement and aintenance of healthful conditions, and in the extension of the use of safety evices, permissible explosives, and approved equipment. This branch cooperates n rescue work at disasters and in fighting mine fires, and it sends representa- ives to places where major accidents, fires, or explosions have occurred to nvestigate and develop information which may be used by the Bureau in its ducational campaigns and research programs for the improvement of health and afety in the mining and allied industries. This branch also has charge of he gas and dust laboratories of the Pittsburgh Experiment Station.

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[6] Schmidt, L. D., Elder, J. L., and Davis, J. D., Oxidation of Coal at Storage Temperatures: Ind. and Eng. Chem., vol. 28, no. 11, 1936, p 1346-1353.

[7] Brewer, R. E., and Atkinson, R. G., Plasticity of Coals: Ind. and En Chem., anal. ed., vol. 8, no. 6, 1936, pp. 443-448.

oal-Mining Methods. In order to obtain first-hand information on the problems confronting coal operators and to develop general knowledge f mining practices in the various mining fields, two engineers of the Mining ivision are devoting all their time to a survey of mining methods. Two publi- ations were issued.[8], [9] A circular on "Typical Shaft-Bottom Layouts" is eady for publication, and another on "Strip Mining" is 75 percent complete. n investigation of "Concentrated 3-shift Mining" has been started. Other tudies under consideration are:

Locomotive vs. Truck Haulage in Strip-Coal Operations
Cutter Bits
Underground Haulage

ires in Anthracite Mines. In cooperation with one of the large anthracite operating companies a study of the origin, main- enance, and extinction of mine fires is in progress. Experimental work has een directed toward the determination of the ease of ignition and the tendency o maintain combustion, not only of various forms of anthracite but also of the arbonaceous shales, pyritic material, and such other naturally occurring com- ustible material as may be found in an anthracite mine. So far the materials ave shown no tendency to ignite spontaneously, although there is the possi- ility that some naturally occurring spontaneously combustible materials may et be found. Extraneous causes, associated with the improper use of explosives nd the accumulation of foreign combustible material, may have been determining auses in many anthracite mine fires, consequently some attention has been iven to these aspects. The field studies have included an examination of ompany records, interviews, and inspections. For the rapid survey of a mine rea, the laboratory investigations have developed the important finding that here is a definite temperature at which a given sample of anthracite or nalogous carbonaceous material begins to evolve carbon monoxide on heating, nd a yet higher temperature at which hydrogen is given off. The finding of ither of these gases in mine air (when explosives are not being used) is a arning that heating is taking place somewhere and if not found and corrected ay lead to a fire. This work was described at the American Chemical Society

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[8] Toenges, Albert L., Longwall Mining Methods in Some Mines of the Middle Western States: Info. Circ. 6893, Bureau of Mines, 1936, 62 pp.

[9] Toenges, Albert L., and Anderson, Robert L., Mining Methods Used in the Grundy Coal Field, Buchanan County, Va.: Info. Circ. 6928, Bureau of Mines, 1936, 43 pp.

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meeting in Pittsburgh last September.[10] Another paper, entitled "Low Temper
ture Oxidation Products from Anthracite and Their Significance in Mine Fire
Studies", by G. S. Scott and G. W. Jones, has been submitted for presentatio
at the Spring, 1937, Meeting of the American Chemical Society.

The Laboratory study also has given some consideration to the propertie
of available slushing materials and sealing materials which may be introdu
to shut off the air supply and so extinguish the fire.

Toxic Gases from Explosives. Recent complaints from coal mines, alleging
that fatalities have been caused by the toxic
gases from explosives, particularly by the oxides of nitrogen, coupled with
a request from the California State Industrial Accident Commission for reco
mendations on the allowable amount of toxic gases from the explosives under
various mining conditions, have created a research problem on the determina
tion of toxic gases from many classes of explosives in mine atmospheres an
in various types of explosives testing equipment at the testing station at
Bruceton. Canadian investigators report a connection between aggravation o
the lung tissue by toxic gases and the incidence of silicosis. When the la
tory and testing-station studies have developed the necessary methods, expe
ments will be made under actual blasting conditions in hard rock in the Mou
Weather testing adit in the Blue Ridge Mountains of Virginia. Factors influencing the nature and quantity of these gases will be determined. The
Institute of Makers of Explosives is cooperating with the Explosives and
Mining Divisions of the Bureau in this study. From the data obtained and
the interest aroused, it is believed that a distinct advance in the control
of fume conditions may develop.

Investigation of Gallery Tests for Permissible Explosives. One of the most
important propo
ties of permissible explosives is their safety when properly used in gassy
and dusty mines. To determine this property, the Bureau fires samples sub
mitted for permissibility tests into a gallery containing gassy and dusty a
mospheres under conditions that promote sensitivity to ignition. It is im
portant that the conditions governing these tests be understood and control
if safety is to be assured and the development of permissible explosives i
to be handicapped. A study of these phenomena presents the important poss
tility that new information of a fundamental character relating to the mec
ism of ignition may be obtained to guide the further development of explos
and of safety measures. Two decades have passed since the Bureau standari
its methods of testing explosives. Since that time the efficiency of mini
explosives has been improved, a number of new ingredients have been introd
and testing techniques in related fields have been developed. The Bureau
fore is reexamining its testing methods, particularly those that involve t
use of the gallery.

"Strength" of Explosives. In rating the useful work which may be done by
plosive, that is, its "strength", a number of i
ant questions arise. Consideration of these indicates a changing standard

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[10] Scott, G. S., and Jones, G. W., Oxidation of Anthracite: Ind. and Eng
Chem., vol. 29, 1937, pp. 106-108.

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omparison as the importance of lump-coal production is emphasized. According-y, the strength tests, particularly the ballistic mortar and the ballistic endulum, are under examination.

ests of the Permissibility of Explosives and Field Sampling. One of the important functions f the Explosives Division of the Technologic Branch is determination of the ermissibility of coal-mine explosives. The present active list of permissible xplosives contains 170 brand names. Changes in the active list that have been uthorized during 1936 placed 21 brands of explosives on the active permissible ist as a result of tests, by changes in brand names, or by transfer from the nactive list. Twelve brands were transferred from the active to the inactive ist. Five of the explosives submitted failed to pass the required tests. In ddition, three new models of Cardox were tested and placed on the permissible ist of blasting devices.

Permissible explosives, to continue permissible, must be so manufactured, andled, transported, and stored to possess in kind and degree all the chemical r physical characteristics of the basic sample. To check this, samples are ollected in the field and retested, thus maintaining the quality of the product. For the past several years field activities were curtailed, owing to the peration of Government economy measures. This service to the user was reumed last year, when 14 samples were collected in the field and retested. en passed, but four did not and were pronounced unsatisfactory and declared onpermissible. Field sampling exercises a salutary control over the permisible-explosives situation and should be expanded when fund and personnel permit.

ermissible Electrical Equipment. Determination of the permissibility of electrical equipment for use in mines is ne of the major continuing projects of the Bureau. The duties of the testing aboratory for this work at the Pittsburgh station have been increased from ear to year, due to the rapid growth of mechanization in coal mines. The ast year has been a busy one; approvals were issued on 5 coal-cutting machines, coal loading and conveying machines, 1 storage-battery locomotive, 1 electric lashlight, and 1 gas detector. Major extensions granted numbered 35. An proved permissible flame safety lamp in which a thermally expanding indicating inter permits more certain and accurate detection of methane in mine air was eveloped by the electrical section. 11/, 12/, 13/

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[11] Ilsley, L. C., Hooker, A. B., and Coggeshall, E. J., The Improved Permissible Flame Safety Lamp: Rept. of Investigations 3312, Bureau of Mines, 1936, 10 pp.

[12] Bureau of Mines, Permissible Electric Flashlights; Procedure in Testing, Fees Charged, and Requirements for Approval: Sched. 11-A, January 1936.

[13] Ilsley, L. C., and Hooker, A. B., Permissible Electric Mine Lamps, Rept. of Investigations 3304, Bureau of Mines, 1936, 11 pp.

The laboratory work is supplemented by field investigations and the ob-servation of permissible equipment in actual service as time permits.[14] This serves two purposes, it keeps the laboratory abreast the industry, thus it helps to make the laboratory work more practical, and it strengthens the permissibility requirements by correlating these with subsequent service. Th laboratory at Pittsburgh also keeps a file of codes and State regulations on electrical equipment[15], [16] in mines and endeavors to be helpful to any Stat that may desire to modify or extend their laws or regulations on such equipment.[17], [18]

The laboratory, as time permits, also fosters research work such as that relating to static electricity in mines.

Experimental Mine. A new departure, inaugurated recently, is the use of the Experimental mine, when conditions are unfavorable for co dust explosion work, for training new members of the Bureau's Safety Branch fighting mine fires and in conducting recovery work after explosions. The f training along this line was completed successfully during January 1937. Nor mally, it is expected that such work will be undertaken during the summer mon The Mine Inspectors' Institute of America has requested that the same type of training at the same place be given to selected personnel of mining companie and plans are being made for such use of the mine in June, July, August, and September.

During the past year tests designed to effect the prevention of coal-du explosions have been made at the Experimental mine as a service to coal operators. Subbituminous coal from Colorado, formerly considered relatively free from hazard because of its high moisture content, is now under test. A explosion last year in Colorado prompted such an examination.

Experiments also have been made with bituminous-coal dusts to determine more precisely the conditions under which coal-dust explosions are initiated by electric arcs and the part that small percentages of methane play in promoting ignition.[19]

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[14] Ilsley, L. C., Gleim, E. J., and Brunot, H. B., Permissibly Operated Ai Compressors, Rept. of Investigations 3309, Bureau of Mines, 1936, 18

[15] Freeman, H. B., Hazard of Igniting Coal by Electric Circuits in Mines: Tech. Paper 568, Bureau of Mines, 1936, 31 pp.

[16] Gleim, E. J., and Brunot, H. B., Electrical Viewpoint in a Complete Saf Survey of a Coal Mine: Inf. Circ. 6894, Bureau of Mines, 1936, 18 pp

[17] Ilsley, L. C., Milestones in Mine Safety Legislation: Inf. Circ. 6904, Bureau of Mines, 1936, 12 pp.

[18] Bureau of Mines, Explosion-proof Mine Equipment; Requirements for Appro of Storage Battery Locomotives and Power Trucks, Junction Boxes and Electric Motordriven Equipment: Sched. 2D (revision of Schedule 2C), May 1936.

[19] Rice, G. S., and Greenwald, H. P., Notes on Testing the Explosibility o Coal Dusts and a Proposal to Have an International Test Method: Inf. Circ. 6878, Bureau of Mines, 1936, 8 pp.

Movement of Strata in Coal Mines. A study has been made in two mines in the Pittsburgh district for the purpose of relating movement of strata to natural conditions and to mining methods, with the purpose of obtaining maximum safety with economy of operation. Proper control of roof movement is one of the most important considerations in coal mining, and the load on retreating pillar lines imposed by the roof has much to do with the ease of mining.

A preliminary report of the work done in one mine was presented at the December meeting of the Coal Mining Institute of America.

PREPARATION OF COAL

Studies on the preparation of coal are conducted at the Seattle (Wash.) and the Tuscaloosa (Ala.) stations. A systematic survey of the washability of Alabama coals is in progress, and special problems arising both in Alabama and Washington are undertaken insofar as they relate to the more fundamental type of coal-preparation research. Two commercial cleaning plants have been placed in operation, using coal-washing methods developed and recommended by laboratory studies at the Northwest Experiment Station of the Bureau.

At one of these plants a readjustment of operating conditions, following the experimental results of the Bureau, increased the efficiency of coal recovery from 90 to 95 percent. In effect, this halved the loss of coal in the refuse without increasing the ash content of the washed coal.

At another plant the installation of an air-pulsion or Baum-type jig has presented an opportunity for studying the performance of this type of cleaning device, which has been introduced into the United States from Europe within the last few years. Preliminary analysis of the data obtained in this study indicates that this type gives a very efficient separation of coal from refuse. Several reports have been prepared as a result of these washability studies, of which the fourteenth in a series is the most recent.[20]

Reduction in the ash content of a coal is of extreme importance to almost every user, whether domestic or industrial. The amount of ash reduction, which a producer can afford to make or the residual ash the user will tolerate, depends on many factors. Much help can be rendered by the Bureau by such an investigation, and plans for this should be included in the program for the coming year.

A study in progress at the Seattle station is the flocculation of slimes in washery water by the addition of starches, proteins, and various other substances.

The literature on dust prevention by the treatment of coal with oil or calcium chloride has been reviewed and a paper published.[21]

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[20] Gandrud, B. W., and Coe, G. D., Washability Studies of Coal from the Acmar No. 5 Mine, Acmar, Ala.: Rept. of Investigations 3315, Bureau of Mines, 1936, 23 pp.

[21] Schmidt, L. D., Dust-Prevention Treatment of Solid Fuels: Inf. Circ. 6932, Bureau of Mines, 1936, 10 pp.

The effect of the oil treatment of coal in the prevention of spontaneou heating is a topic that should receive attention. Among other questions, su a study should ascertain the minimum effective amount of oil required for a given coal.

UTILIZATION OF COAL

The Bureau carries on research work on the carbonization of coal, on coke, and on byproducts, on the fundamentals of combustion in fuel beds, and on coal hydrogenation. It also maintains a fuel-economy service for Government heating and power plants.

Survey of Gas- and Coke-Making Properties of American Coals. The survey of and coke-maki properties of American coals, begun a few years ago, has been actively conti Typical American coals, now over 30 in all, have been examined and include b low- and high-volatile coals, as well as blends of each. The selection of t blends studied was made on the advice of the Advisory Committee of the American Gas Association. Several publications have already resulted from the su vey.[22], [23]

One paper was presented to the Chemical Engineering Congress of the Wo Power Conference in London, June 1936.[24]

In the survey, the yields and the properties of coke, gas, and byprodu obtained under low, mid-, and high-temperature carbonizing conditions are determined. The results are therefore of value not only to the present high-temperature gas- and coke-manufacturing processes but also to mid- and low-temperature processes. A large-scale coal oxidizer and conditioner has bee built; with this, information on the effect of pretreatment of coal will be extended. The effect of preheating on coke quality will be studied also.

Burning Properties of Coke. A study of the physical and chemical propertie of coke produced from western coals is in pro at the Seattle station. From this has been developed a new method for estimating the rate at which solid fuels burn in air. The study has shown that with cokes produced under the same conditions, combustibility tends to decrease with increase in rank.

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[22] Fieldner, A. C., Davis, J. D., Thiessen, R., Selvig, W. A., Reynolds, Jung, F. W., and Sprunk, G. C., Carbonizing Properties and Petrograp Composition of Clintwood Bed Coal from Buchanan Mines Nos. 1 and 2, Buchanan County, Va.: Tech. Paper 570, Bureau of Mines, 1936, 34 p

[23] Fieldner, A. C., Davis, J. D., Thiessen, R., Selvig, W. A., Reynolds, D. A., Jung, F. W., and Sprunk, G. C., Carbonizing Properties and Petrographic Composition of Pittsburgh Bed Coal from Pittsburgh Terminal No. 9 Mine, Washington County, Pa., Tech. Paper 571, Bureau o Mines, 1936, 33 pp.

[24] Fieldner, A. C., and Davis, J. D., The Bureau of Mines-American Gas Association Carbonization Test and Its Use in Determining the Effect o Blending Coals on the Yields and Properties of Coke, Gas, and Byprod (in press).

At the Pittsburgh station, the effect of the temperature of carboniza- ion on the kindling temperature and the rate of burning has been determined n a series of cokes made from different coals and blends of coals.[25], [26] mprovement in the properties of domestic coke can be made by the proper se- ection and blending of different kinds of coal.

panding Properties of Coal under Coke-Oven Conditions. During coking, certain coals expand cessively and injure industrial coke ovens and gas retorts. When used for rbonizing purposes, these coals must be mixed or blended with enough non- panding coal to render them harmless. An apparatus for studying the ex- ansion of coal has therefore been designed in the Bureau of Mines labora- ory at the request and with the advice of the Carbonizing Committee of the merican Gas Association. This equipment is now in operation, and during he coming year it is planned to study the expansion characteristics of arious coals and blends.

mbustion of Coal. Studies were conducted on fundamental principles of combustion, taking up overfeed-stoker problems similar o those completed on the underfeed.[27], [28] A report on the use of anthra- ite and of high- and low-temperature cokes in domestic furnaces is in reparation; the influence of size is a special feature of this report. When he requisite force and time are available studies will be made of the travel- ng-grate, cross-feed principle. Further study of underfeed combustion also s desired to complete the knowledge available on the action of the fuel beds n commercial underfeed stokers.

An investigation, soon to be described in a publication, is being con- cted on the practical effect of various chemicals, such as calcium chloride, orax, sodium carbonate, boric acid, and molybdenum oxide on combustion. ork was resumed on the removal of ash as molten slag from powdered-coal furnaces. he chemical analyses for forms of iron, which have not been completed, will ake it possible to interpret the effect of temperature on the thermal dis- ciation of ferric oxide in coal-ash slags, as determined in previous tests, llowing an arbitrary period of 1 hour for each stage in the dissociation- rve determination.

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[25] Reynolds, D. A., and Davis, J. D., Reactivity of Coke: Ind. and Eng. Chem., anal. ed., vol. 8, no. 1, 1936, pp. 33-36.

[26] Holmes, C. R., and Davis, J. D., Kindling Properties of Coke; Ind. and Eng. Chem., anal. ed., vol. 28, no. 4, 1936, pp. 484-488.

[27] Nicholls, P., Underfeed Combustion, Effect of Preheat, and Distribution of Ash in Fuel Beds: Bull. 378, Bureau of Mines, 1934, 76 pp.

[28] Nicholls, P., Principles of Fuel Beds: Fuel Economist, vol. 11, January 1936, pp. 141-145; February 1936, pp. 186-188.

Certain laboratory studies, which were completed prior to this year,
the basis of several publications issued by members of the fuels section.
31/, 32/, 33/

At the Seattle station an experimental study is in progress on domest
stokers for use with subbituminous and noncoking types of coal such as are
duced in the Pacific Northwest.

Fuel-Economy Service. During 1936, as heretofore, the Fuel-Economy Servic
vided to Government agencies, upon request, advice
assistance in the utilization of purchase of fuel and of fuel-burning equ

The lowering of fuel costs is effected by selecting the proper equi
for the fuel to be used, or conversely, by selecting the proper fuel for
equipment already installed. Power-plant studies, fuel-efficiency tests,
studies, acceptance tests on new equipment, boiler feed-water service, a
on the purchase of new equipment, and consultation on the preparation of
fications are continuous functions of the unit and yield direct savings.
on the design, testing, and initial operation of new plants increased dur
year. Advisory service was rendered in efficient industrial fuel utiliza
and on the improvement of combustion methods, as, for example, municipal
abatement.34/

Random mention only can be made to illustrate the economic significa
variety, and location of the plants, and operations inspected. In one ci
in September 1936, John F. Barkley, fuel-economy engineer, visited the ce
heating plant of the Navajo Capital at Window Rock, Ariz.; various Indian
Service plants in the vicinity; Veterans' Hospitals at Los Angeles, Palo
San Francisco, American Lake (Wash.); Tacoma Indian Hospital; Justice Dep
ment prisons at the outpost Alcatraz, San Francisco, and McNeil Island
(Steilacoom, Wash.).

Developmental research, growing from the needs of the work, is carrie
and recently included new testing apparatus for making water analyses at
plants, methods of testing the efficacy of new water-conditioning equipme

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29/ Nicholls, P., Heat Insulation: Kent's Mechanical Engineers' Handbo
vol. 2, 11th ed., sec. 3, 1936, pp. 54-71.

30/ Rice, W. E., Review of Data on Combustion in Kilns: Bull. Am. Cera
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and cooperative research plans on stokers. Possible correlations between the action of coal in combustion and the agglutinating and agglomerating indices are under investigation.

Representatives of various Government departments are seeking increased guidance and service in boiler-feed-water conditioning, and some expansion in personnel to permit road trips is desirable. A new publication has been issued, primarily for the use of Government steamplant engineers, and has proved very popular among industrial engineers also.[35]

Hydrogenation of Coal. In European and Asiastic countries much emphasis is being laid on the importance of providing against exhaustion of liquid fuel supplies. Although necessity in this country is less, it is important that American research in this field be maintained to establish proper groundwork for the evaluation of foreign developments. Another important objective of the study on the hydrogenation of coal is the obtaining of comparative data on various American coals to determine which are the most amenable to the hydrogenation treatment and to determine the optimum conditions of treatment for each. Heretofore, almost all hydrogenation studies in this country have been made by the oil industry. Investigations to be conducted by the Bureau of Mines will be dedicated to public use and for the benefit of the coal industry. By starting the program at this time, it is contemplated that during the next decade, sufficient-new developments will result so that the American coal industry will be in a position to make a liquid fuel when the necessity arises.

During the past calendar year, a small-scale continuous unit has been designed and erected, capable of hydrogenating 100 pounds of pulverized coal in 24 hours. This equipment, together with apparatus for making the hydrogen, is housed in a special building.

In connection with the design of the hydrogenation equipment, several subsidiary problems were studied. As part of the making of hydrogen, it became necessary to develop a method for continuously removing carbon dioxide from the gas by a simple scrubbing system. This has been successfully accomplished.[36] Another problem that was solved in connection with these studies, was the development of a suitable catalyst to be used in making the hydrogen.[37] In further development of another phase of the hydrogenation problem, special analytical methods were studied and devised for analyzing the various oil products that resulted from the coal hydrogenation. An extensive treatise on this subject will probably result. Already the first chapter is complete and will be relased for publication shortly to avoid the delay that would be necessitated if the entire book were to be published at one time.

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[35] Barkley, J. F., Questions and Answers on Boiler Feed-Water Conditioning: Question and Answer Handbook 3, Bureau of Mines, 1936, 121 pp.

[36] Hirst, L. L., and Pinkel, I. I., Absorption of Carbon Dioxide by Amines: Ind. and Eng. Chem., anal. ed., vol. 28, 1936, pp. 1313-1315.

[37] Storch, H. H., and Pinkel, I. I., A Method for the Preparation of an Active Cobalt-Copper Catalyst for the Water-Gas Shift Reaction: Jour. Am. Chem. Soc. (in press).

For the coming year, one of the important needs for the program in coal research is a staff large enough to competently develop the problems connecte with coal hydrogenation. The plant is now ready to operate and a sufficient number of technicians should be made available for continuous operation in three shifts.

Thermal Decomposition of Hydrocarbons. The rate of thermal decomposition of ethane is being studied. This fundamental research problem is a pioneer quantitative, critical study of the ther decomposition of hydrocarbons, and it is contemplated that it will form the foundation of a correct theory of the mechanism of this type of decompositio Intangible as the immediate results are, the eventual possibilities are so broad that industry is highly anxious to have this work expanded. Not only industrially, but also in the interest of conservation of petroleum and natu gas resources is this work important. It is essential that a continuous supply of fundamental scientific data be provided to facilitate the rapid devel ment of industrial processes which use as raw materials coal gas, natural ga or the refinery gases obtained in the cracking of petroleum. Owing to the complexity of the reactions which occur during the thermal decomposition an polymerization of hydrocarbon gases, graduate students in universities are not attracted by this field of research and this responsibility rests the more heavily on the Bureau of Mines.

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